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Mr. Philip H. Mook, Jr.
Western Execution Branch Chief
Air Force Civil Engineer Center
United States Department of the Air Force

SUBJECT: Former Williams AFB Site ST012, Liquid Fuels Storage Area; Data Needs to Resolve Informal Dispute over Enhanced Bioremediation

Dear Mr. Mook:

The US Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ), "The Agencies", are in receipt of your February 10, 2017 letter stating Air Force's (AF's) intention to move forward with implementation of the Enhanced Bioremediation (EBR) work plan for ST12, despite the objections raised in our letter to you dated February 8, 2017 and the January 25, 2017 technical responses sent to Cathy Jerrard. In follow up to discussions during the February 14, 2017 Base Closure Team (BCT) meeting, we are hereby providing you with a list of issues, data gaps and missing information needed to resolve the informal dispute over the path forward for the former Fuels Spill Site, attached to this letter.

The Agencies invoked informal dispute over the AFs proposed work plan on the basis that:

- 1) the Steam Enhanced Extraction (SEE) System was prematurely terminated before performance criteria specified in the work plan had been met;
- 2) the estimates of mass remaining post SEE are still too great to expect EBR alone to meet the Remedial Action Objectives (RODA~~RAO~~) specified in the 2013 Record of Decision Amendment (RODA) within a reasonable timeframe, let alone the 20-year timeframe specified in the RODA;
- 3) the site has been heated to boiling temperatures and can be expected to remain hot for many years, and thus, contaminants are now significantly more mobile than they were before SEE.
- 4) The mass of remaining petroleum hydrocarbon Light Non-Aqueous Phase Liquids (LNAPL) will be a persistent continuing source of dissolved phase benzene groundwater contamination for decades to come;

Commented [WU1]: Not sure why we are including this; the "reasonable timeframe" would be greater than 20 years after the RODA, I assume. According to what I remember AF indicating in the meeting, a reasonable timeframe (for them) would be 50-100 years or so. Continued aggressive EBR over 50-100 years might well work – though of course none of us would be around to see for sure. I think the "reasonable timeframe" phrase merely provides more fodder for endless arguments.

Again, note that I don't think it is absolutely impossible that EBR/MNA could work in 20 years, merely that it is highly uncertain that it would do so. Therefore it is imprudent to allow EBR to go forward without stringent performance monitoring/contingency triggers, with a success/failure decision for EBR to be made within a short timeframe relative to the 20-year RODA timeframe so as to allow time for design and implementation of the contingency remedy(ies) quickly enough to meet the RODA timeframe for remedy completion.

And, of course, if EBR does in fact deplete the LNAPL in say 3 years (so that MNA for the rest is reasonable), then we will all be happy.

But note carefully that if the 20-year RODA timeframe goes away (that is, regulators agree to some extended, perhaps quite fuzzy timeframe), then the uncertainty of EBR/MNA becomes (basically) a non-factor. So my concerns about EBR/MNA are much reduced if the RODA timeframe is extended significantly, whether explicitly (e.g., in an RODA amendment) or implicitly in some sort of a tacit compromise with AF.

However, either hydraulic containment or very detailed performance monitoring for plume expansion are necessary in any case.

- 5) Enhanced Bioremediation can only be expected to degrade contaminants in the dissolved phase and rate of LNAPL dissolution is expected to be very slow; the rate of anaerobic degradation in the dissolved phase is also anticipated to be slow, with benzene, the primary contaminant of concern (COC), being the slowest of the BTEX compounds to biodegrade.
- 6) consistent distribution of amendment throughout the LNAPL smear zone is technically challenging and will be difficult to achieve due to biofouling issues already observed at the site;
- 7) if the rate of natural or enhanced biodegradation is slower than the rate of groundwater contaminant transport a downgradient benzene groundwater plume will result that will be costly to address in the long term;
- 8) The large quantities of sulfate amendment expected to be added under the proposed work plan are also expected to degrade water quality downgradient of the site if not contained.

Commented [WU2]: Perhaps "5) Enhanced Bioremediation can only be expected to significantly degrade the contaminants of concern (COCs) in the dissolved phase, so the rate of COC/LNAPL dissolution is likely to be the rate-limiting step, as indicated by AF; the presence of large accumulations of LNAPL (e.g., as indicated by continuing significant mobilization of LNAPL into wells) means that COC/LNAPL dissolution into groundwater from these LNAPL accumulations will be slow and long-term due to long diffusion paths from within LNAPL accumulations into groundwater; benzene, the primary COC, is likely to be the slowest of the BTEX compounds to biodegrade, perhaps allowing benzene to travel farther downgradient before degradation."

Commented [WU3]: Perhaps "6) consistent distribution of EBR reagents throughout the LNAPL zone, technically challenging due to variations in stratigraphy, hydraulic conductivity, and LNAPL presence, will be difficult to achieve, and will be exacerbated due to biofouling issues already observed at the site."

The agencies are not only concerned that the proposed work plan for EBR will likely fail to meet the RAOs specified in the RODA, but also will worsen downgradient groundwater conditions. In your letter of July 1, 2016 and our subsequent telephone conversations, AF initially agreed to discontinue procurement for EBR pending resolution of the dispute and to instead proceed to construct a hydraulic containment system to resolve this concern. We are dismayed to learn following the February 14, 2017 BCT meeting that AF has since reversed its position and no longer intends to operate the system as constructed for hydraulic containment as documented in the Remedial Action Field Variance Memorandum #5 – Extraction and Treatment System Construction, dated September 30, 2016. It appears that AF has misled the agencies and instead of the containment system, constructed the EBR injection and distribution system we had requested be put on hold pending resolution of the dispute.

In the February 14, 2017 BCT meeting AF also indicated the intent to reduce the frequency of monitoring, despite concerns raised by the Agencies that monitoring data and rising temperatures in perimeter wells are already beginning to demonstrate loss of hydraulic containment.

These reversals of prior agreement appear to contradict AF's stated commitment to the remedial objectives at ST-12. Based upon responses to the concerns raised by the agencies, we are unsure at this time if the AF cares whether the proposed EBR remedy will be effective or not given the uncertain long timeframe and vague approach to attainment of remedial objectives presented in the work plan.

The agencies are still committed to the FFA process and hope that AF will continue negotiations in good faith to resolve this dispute. Please advise if we have misunderstood or misrepresented AF's current position.

Sincerely,

Angeles Herrera
Assistant Director
Superfund Division
United States Environmental Protection Agency

Tina LePage
Waste Programs Division
Remedial Projects Section Manager
Arizona Department of Environmental Quality

cc:

Issues and Data Needs to Resolve the ST12 Informal Dispute

Issues:

- 1) The January 2014 Draft Final RDRA Workplan for SEE specified that once SEE was terminated, the wells in the cell phone lot would be connected to the SEE extraction system via underground piping in order to reopen the cell phone lot and that post SEE extraction would continue for 90 days. (Page 4-11, lines 1404 – 1410) Long term hydraulic containment was included in the original proposal for EBR as stated in this work plan. However, the extraction system was abruptly terminated and rapidly dismantled after only 8 weeks of post SEE extraction. No technical rationale has been provided for these changes to the Work Plan. Please provide AF's technical basis for termination of the extraction system at only 8 weeks as well as the rationale for removing hydraulic containment from the RDRA Workplan Addendum 2.
- 2) The January 2014 Draft Final RDRA Work Plan for SEE specified an EBR injection design utilizing a 5 point pattern of injection well design utilizing a 60 foot well spacing, and stated “ *Beyond an approximate well spacing of 75 feet results from the model revealed that sufficient extraction pumping could not be achieved because of limitations associated with the permeability and storage of the aquifer and subsequent loss of injectate to the natural gradients in these gaps between extraction well capture zones.* ” (Appendix E page 4-1; Section 4.1) The 2014 Work Plan proposed a total of 61 wells for amendment injection or extraction, including 5 in the Cobble Zone (CZ), 28 in the Upper Water Bearing Zone (UWBZ), and 28 in the Lower Saturated Zone (LSZ). (Appendix E pages 4-2 -4-4) These 61 wells appeared to be necessary to attain optimal amendment distribution to meet remedial objectives in the 2014 Draft Final RDRA Work Plan. In contrast, the design proposed in the March 2016 Addendum 2 Work Plan employs only 27 wells for amendment distribution, spaced more widely apart than the 2014 model recommendation, placed to treat ~~of~~ the perimeter areas, and does not appear to be designed to reach LNAPL remaining in the interior of the site. The Field Variance Memorandum #5, Final January 2017 documents a constructed network of 18 perimeter wells, presumably for hydraulic containment as indicated in that document, but AF has since indicated these are now planned solely for implementation of EBR. No technical basis has been provided to explain the downscaling of the EBR effort with each successive work plan draft.
- 3) The January 2014 Draft Final RDRA Work Plan provided preliminary performance criteria of implementation of EBR in table E-4.15, which specifies milestones to be attained in benzene concentrations within specific timeframes. However, we found no performance criteria specified in ~~the~~ the March 2016 Draft Final RDRA Workplan

Commented [WU4]: I suspect that they will eventually end up with the idea that it really doesn't matter how much LNAPL remains, as long as the COC plume is not expanding "significantly".

Addendum 2. Normally we would expect the earlier plan to be more conceptual and less specific than the later versions of the document, but it appears that in this case the objectives and performance criteria have become less specific as the scope of the proposed effort has been scaled back over time. The objectives of the current proposed effort are unclear at this time. It is unknown if AF is still committed to the performance milestones stated in the table below, or if the current reduced effort is even capable of attaining these objectives:

Commented [WU5]: The whole thing has become totally fuzzy, so that there is no site condition that could be considered a specific trigger for EBR remedy failure, or anything else.

Note that, in our meeting, Don indicated to me that they were still shooting for benzene concentrations of "500 or 600 ug/L" in the interior before beginning MNA.

Commented [WU6]: Note that even this table is useful for performance monitoring/triggers only if they are very specific about how these things will be determined; e.g., how the "Average" and "Maximum" values are to be determined. It would be relatively easy to place the Average value anywhere desired, by choosing sampling points.

For example, I would be in favor of monitoring all wells that have ever shown LNAPL or benzene (frequency of sampling could vary – not necessarily all wells every quarter), in order to assess EBR/MNA performance across the whole site. But averaging of COC values from all wells would almost certainly drive the Average way down.

Again, what happens if the Maximum is exceeded in (for example) one well in one zone? Will, for example, that zone be considered separately from the other zones, in terms of EBR success or failure?

What happens if some COC values bounce around the Maximum from sampling event to sampling event?

So, even this table, though the numbers appear very precise (e.g., 1.25, 3.3, etc.), is not immediately useful for performance monitoring/triggers without much more specificity in exactly how the samples will be taken, evaluated, and results applied to site decisions.

Table E-4.15 Predicted Maximum and Average Dissolved Benzene Concentrations Following Sulfate-Reducing EBR

Hydrostratigraphic Zone	Date (month/year)	Predicted Benzene Concentration (µg/L)		Notes
		Average	Maximum	
Cobble Zone	04/2017	21	27	End of EBR Recirculation/TEA Addition
	04/2025	1.25	7.8	~8 years following EBR
	01/2031	0.08	0.95	~15 years following EBR
Upper Water Bearing Zone	04/2017	210	1,400	End of EBR Recirculation/TEA Addition
	04/2025	5.5	9.5	~8 years following EBR
	01/2031	1.0	3.3	~15 years following EBR
Lower Saturated Zone	04/2017	31	270	End of EBR Recirculation/TEA Addition
	04/2025	1.9	6.8	~8 years following EBR
	04/2031	0.64	2.8	~15 years following EBR

Notes:
 ~ = approximately
 µg/L = micrograms per liter
 EBR = enhanced bioremediation
 TEA = terminal electron acceptor

Immediately following sulfate-reducing EBR recirculation (Table E-4.15) the model predicts that dissolved benzene concentrations are below approximately 27 µg/L in the CZ, 1,400 µg/L in the UWVZ, and 270 µg/L in the LSZ. Within eight years following sulfate-reducing EBR dissolved benzene concentrations drop and the maximum concentration of benzene predicted in the UWVZ is 9.5 µg/L. By 2031, the benzene concentrations in each of the hydrostratigraphic zones are predicted to be below 3 µg/L.

Data Needs to resolve the dispute:

- 1) Because several different versions of the Addendum 2 Work Plan have been provided and each successive version appears to document a reduced effort and commitment, all of the information relevant to the current proposal needs to be provided in a single document.
- 2) The current remaining mass estimate still needs to be verified by post SEE sampling. Baseline conditions identifying specific locations and depths of LNAPL bodies and benzene concentrations remaining in LNAPL by location is needed to be able to target areas for treatment and evaluate remedy performance.

- 3) Please provide an evaluation of amendment mass loading on groundwater chemistry over time, taking into account groundwater transport.
- 4) Please provide an updated estimate of a realistic timeframe to meet the remedial action objectives under the current proposed effort. Please provide all modeling efforts and assumptions in complete package, including all inputs and outputs of the model for each iteration of the model over the years, and all calibration efforts and sensitivity analyses. In particular, because the movement of COCs from within the LNAPL into groundwater is considered to be the rate-limiting step for EBR, provide a discussion of how COC movement from LNAPL to groundwater was evaluated in the model, and how sensitivity analyses of this movement rate were conducted.
- 5) Please indicate the milestones proposed to be used to monitor success of the EBR against baseline conditions.

Commented [WU7]: Note that AF indicated (according to my memory of the meeting) that the "equilibrium" value for COCs in LNAPL/water was hard-coded into the model. So, if I correctly understood what they were saying, they had no way to properly evaluate in the model (e.g., sensitivity analyses by varying the rate of dissolution of COCs from LNAPL into groundwater) the factor that they admit is the rate-limiting factor for LNAPL COC biodegradation.

However, I am not a modeler. It would be useful to have the various model iterations evaluated by an expert modeler.

Commented [WU8]: Again, the devil is in the details of exactly what wells will be sampled, how the samples will be evaluated, decisions made, and so on. Remember the problem with the "10% of maximum SEE removal" stopping point for SEE.

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